Journal of the Royal Society of Western Australia, 73 (3), 1991, 73-75

The epizoic diatom *Falcula hyalina* Takano on a pelagic copepod from the Swan River estuary, Western Australia

Jacob John

School of Biology, Curtin University of Technology
Bentley, WA 6102

Manuscript received December 1989; accepted February 1990

Abstract

The diatom *Falcula hyalina* Takano growing attached to the copepod *Sulcanus conflictus* is recorded from the Swan River estuary. This is the first record of an epizoic diatom in Australia. The morphology, ultrastructure, taxonomic status and known geographical distribution and ecology of the diatom are discussed.

Introduction

Many diatoms grow attached to seaweeds, clams, rocks, shells, sediments and even the skin of dolphins and whales. Diatoms growing attached to pelagic copepods are relatively rare (Simonsen 1970). Such associations between diatoms and copepods are often host-specific and speculated to be symbiotic (Ikeda 1977). One such diatom is *Falcula hyalina* Takano reported to be growing attached to different species of calanoid copepods (Takano 1983, Hiromi et al 1985, Prasad *et al.* 1989).

Voigt (1960:61) established the araphid genus *Falcula* and described the four species, *F. rogallii, F. media, F. semiundulata,* and *F. paracelsiana.* These species were epiphytes, characterized by a sinuous apical axis and an eccentric axial area arranged closer to the ventral margin of the valve. Voigt remarked that the genus *Falcula* was related to *Synedra* and *Pseudohimantidium.* Simonsen (1970) established the family Protoraphidaceae to include *Protoraphis* and *Pseudohimantidium,* both of which tend to show apical rows of labiate processes on each pole and are predominantly epizoic (Gibson 1979).

The present species of diatom was first encountered as growing attached to the calanoid copepod *Sulcanus conflictus* in the Swan River estuary in 1981 and its ultrastructure investigated (John 1984). However, Takano found it epizoic on the calanoid copepod *Acartia steueri* in the coastal waters of Shimoga City and described it as *Falcula hyalina* in 1983. The genus *Falcula* has provoked a great deal of interest among diatomists, due to its apparent resemblance to eunotoid diatoms (Round & Sims 1979). Because information on epizoic diatoms is generally sparse, it is worthwhile reporting the occurrence of an epizoic diatom from Australia, for the first time. This paper also deals with some aspects of the taxonomic status and distribution of *Falcula hyalina.*

Materials and Methods

During an extensive survey of the Swan River estuary (31°45'S, 116°04'E) plankton samples were collected using a net of 45 µm mesh in 1980-81. The hydrology and physico-chemical properties of the Swan River estuary were presented in John (1983: 84 & 87). Copepods collected were examined and *Sulcanus conflictus* infested with *Falcula hyalina* were photographed using a Nikon photomicroscope. The epizoic diatoms washed from the copepod were cleaned and examined by light, and scanning electron microscopy as described by John (1983).

Observations and Discussion

The posterior metasome, urosome and the furcal rami of the copepod *Sulcanus conflictus* were infested with the diatom (Fig. 1A). The frustules were attached to the copepod by one end in clusters (Fig. 1B). The cells were very thinly silicified and delicate with two plate-like light green chromatophores in each cell (Fig. 1C).

Valves are arcuate, linear with obtuse apices. The dorsal margin is broadly convex and ventral margin slightly concave. The axial area is broad, not clearly defined and located closer to the ventral margin. The valve face is striate; striae areolate and difficult to resolve under light microscope. The areolae become increasingly smaller towards the axial area (Figs. 1 D,E,F)

SEM studies (Fig. 1G) reveal that there is a small, deeply set porefield on each pole of both valves. A distinct labiate process is also present, but only on one pole of each valve (Fig. 1D) The labiate processes are located on alternate poles of the two valves of the frustule. The labiate process opens externally by a circular pore and is developed into a small lip-structure internally, with its slit oriented

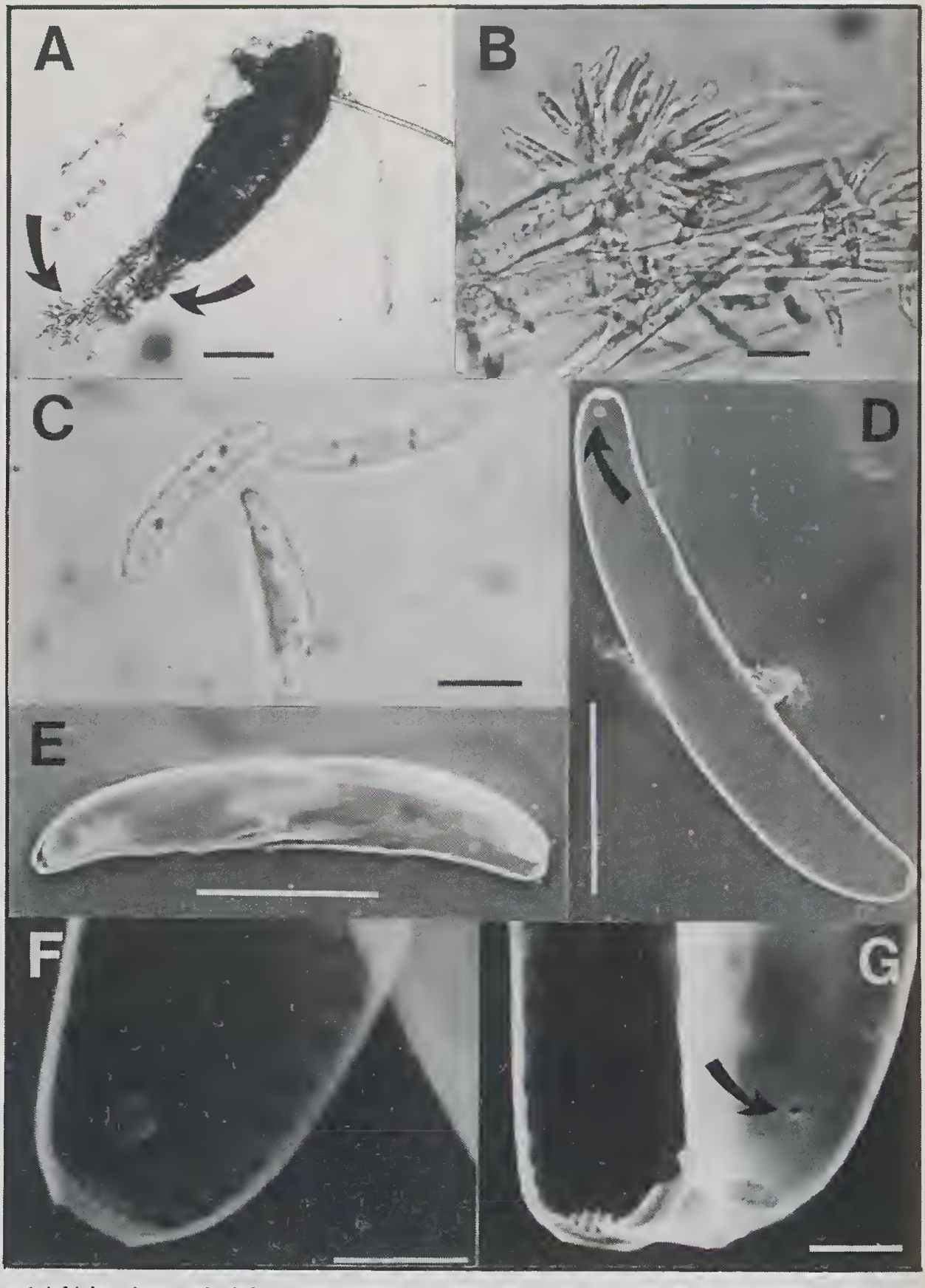

Figure 1 A Light micrograph. *Sulcanus conflictus* infested with the epizoic diatom *Falcula hyalina* (arrow points to the furcal rami of the copepod). Scale bar = 100 µm. B Light micrograph. Clusters of diatoms attached to the urosome and furcal rami of the copepod. Scale bar = 10 µm. C Light micrograph. Fresh frustules showing chromatophores. Scale bar = 10 µm. D Scanning electron micrograph (SEM). Internal surface view of valve showing the labiate process on one pole (arrow). Scale = 10 µm. E SEM. Whole frustule. Scale = 1 µm. F SEM. Internal structure of the areolae, the labiate process and the porefield. Scale = 1µm. G SEM. Apex of a frustule showing the porefields of both valves and external opening of the labiate process on one valve. Scale = 1µm.

transapically or obliquely (Figs. 1F,G). Areolae are shallow and small. Length 20-30 µm, breadth 2.7-4 µm, striae 22-24 in 10 µm, areolae 6-7 per µm and apical pores 6-8 per µm.

The features described above suggest that *Falcula* can be considered as a valid genus in its own right and is not closely related to *Protoraphis* and *Pseudohimantidium*, as the latter two genera have labiate processes totally different in structure from that of *Falcula* (Simonsen 1970, Gibson 1979). It appears to be closely related to *Synedra*, and *Hannaea* - a genus established by Patrick (1966). *Falcula hyalina* is very similar to *Synedra* in the mode of attachment to the substrate, labiate process and polar porefields. However, the sinuate apical axis, and the highly eccentric and broad axial area distinguish it from *Synedra*. Its resemblance to *Hannaea* due to the presence of a sinuate apical axis is striking. However, ultrastructural studies on the latter are required to draw further comparison. It is evident that the resemblance of *Falcula* to any eunotoid diatom is only superficial. Similar studies on other species of *Falcula* may clarify this point further.

Though this is the first epizoic diatom reported from Australia, it is of wider distribution. Reimer and Mahoney of the Academy of Natural Sciences, Philadelphia have collected this species from the Indian River, on the east coast of Florida, USA and have also investigated its ultrastructure prior to the publication of Takano's description of the species (Reimer, pers comm). They found it epizoic on *Acartia tonsa*. Recently this species has been reported from Choitawhatchee Bay, north eastern Gulf of Mexico epizoic on *Acartia tonsa*. (Prasad *et al.* 1989).

Takano (1983) collected *Acartia steueri* infested with *Falcula hyalina* in 1982 from the waters of Shimoga City, Japan. Hiromi *et al.* (1985) further recorded this diatom epizoic on *Acartia plumosa* and on species of *Oithona* in Lake Hamako and Mikawa Bay Japan. In all the above cases the copepods were found infested with the diatom only towards the end of the growing season in summer. It is interesting to note that in the Swan River estuary, Western Australia, *F. hyalina* was found only on *Sulcanus conflictus* and not on the other two calanoid copepods *Acartia clausi* and *Gladioferens imparipes* present in the Swan River. But the infestation occurred only during the autumn season from April to May at the time of the decline of the copepod population. It is reasonable to assume that the source of infestation might be the sediment. The infested copepods were found in the shallow upper reaches of the Swan River within the temperature range of 19-25°C and a salinity range of 19-30 ppt.

The sediments collected at the time of collection of infested copepod had a sparse distribution of *F. hyalina*. However a detailed examination of the sediments before and after the infestation of the copepods failed to locate any specimen of the diatom. Locating this delicate species in the sediment might be difficult. The habitat of the diatom apart from its epizoic episode remains unknown. From the known habitat of this species, it appears to be host-specific. The adult copepods staying at the bottom of the water during the day (Rippingale & Hodgkin 1974) might provide ample opportunity for the diatom in the sediment to become attached to the copepod. Once infested, the diatoms might multiply fast, and the movement of the host might be beneficial to the epizoic diatom for nutrient availability. On the other hand heavy infestation could impair the ability of the copepod to move and may hasten the decline of their population.

Whether the association is symbiotic-mutually beneficial - or a case of infestation detrimental to the host, is difficult to assess at this stage. Only further investigation on the mode of infestation and other habitats of the diatom can resolve this problem.

Acknowledgements I am grateful to Drs C.W. Reimer, R. Mahoney (Academy of Natural Sciences, Philadelphia, USA) and H. Takano (Tokai Regional Fisheries Research Laboratory, Japan) for their prompt response to my enquiries regarding the species, and Dr R. Rippingale (Curtin University of Technology WA) for identification of the copepod and Prof A.J. McComb (University of WA) for his advice when diatom studies were undertaken in the Swan River estuary.

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